Nonhydrostatic Numerical Investigations of Oscillating Flow Over Sills: Generation of Internal Tides and Solitary Waves

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LONG-TERM GOALS

The goal of this project is to identify processes relevant to the generation, propagation and dissipation of finite-amplitude internal solitary waves observed in the region from the Luzon Strait to the Chinese continental shelf.

OBJECTIVES

The objectives are 1) to demonstrate the feasibility of generating finite-amplitude internal waves by oscillating tides in a nonhydrostatic model developed by us, 2) to describe the generation and propagation of nonlinear internal waves in the northern South China Sea in idealized settings, and 3) to provide information on wave characteristics to principal investigators in NLIWI (Nonlinear Internal Waves Initiative) for planning of field experiments.

APPROACH

Processes of wave generation, propagation and dissipation are studied by numerical simulation using a nonhydrostatic ocean model under different scenarios of bottom topography and stratification. Refinement of the numerical model is simultaneously carried out to enhance the model capability for more complicated cases. Experiments include wave generation at ridges in the Luzon Strait and at density fronts and wave propagation across the deep basin with a shoaling thermocline.

WORK COMPLETED

This project is a pilot study before the start of NLIWI field experiments in the northern South China Sea. One important task of this project is to finish development of a nonhydrostatic model for the study of internal solitary waves. The model development is completed this year. The object-oriented programming technique has been successfully implemented for nonhydrostatic ocean modeling in both Matlab and C++. A paper summarizing this novel approach has been published (Shaw and Chao, 2006).

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The nonhydrostatic model has been proved to be robust for the simulation of internal solitary waves. In previous years, we have described the generation of internal solitary waves from a ridge by tidal currents and from a sharp Kuroshio front and the propagation of these waves in an ocean with a shoaling thermocline. The simulation of mode-2 waves is also successful as well as wave reflection and diffraction from a circular island like the Dongsha Island. A paper describing how a circular island reflects and diffracts solitary waves is now in press (Chao et al., 2006a).

Studies of wave evolution and transmission through the Luzon west ridge are carried out under the support of this project and a follow-up NLIWI project, entitled "Internal Tides and Solitary Waves in the Northern South China Sea: a Nonhydrostatic Numerical Investigation." The study of waves in a two-ridge system emphasizes the blocking of the west ridge on waves generated by the east ridge. A manuscript describing the ridge effects from the nonhydrostatic modeling result together with those derived from a regional hydrostatic model by D. S. Ko and the observation by R.C. Lien has been submitted (Chao et al., 2006b).

RESULTS

Results from the studies of wave evolution and transmission through the Luzon west ridge are described in the report for "Internal Tides and Solitary Waves in the Northern South China Sea: a Nonhydrostatic Numerical Investigation."

IMPLICATION/APPLICATIONS

See the report for "Internal Tides and Solitary Waves in the Northern South China Sea: a Nonhydrostatic Numerical Investigation."

RELATED PROJECTS

This project is a pilot study before the start of NLIWI field experiments in the northern South China Sea. A follow-up of this project is "Internal Tides and Solitary Waves in the Northern South China Sea: a Nonhydrostatic Numerical Investigation" (ONR contracts N00014-05-1-0279 to Shenn-Yu Chao and N00014-05-1-0280 to Ping-Tung Shaw). This project is in close cooperation with the principal investigators of "Variations around the Northern South China Sea" (VANS, T. Y. Tang, lead investigator) in Taiwan and principal investigators in NLIWI. Satellite and radar imagery and mooring data obtained in NLIWI field experiments have been used. This study also utilizes results from the nowcast/forecast model of Naval Research Laboratory by D. S. Ko and the field observation in the South China Sea by R. C. Lien.

PUBLICATIONS

P.-T. Shaw and S.-Y. Chao (2006) A nonhydrostatic primitive-equation model for studying small-scale processes: an object-oriented approach. Continental Shelf Research 26, 1416-1432. [published, refereed]

S.-Y. Chao, P.-T. Shaw, M.-K. Hsu, and Y-J Yang (2006a) Reflection and diffraction of internal solitary waves by a circular island, Journal of Oceanography. [In press, refereed]

S.-Y. Chao, D.-S. Ko, R.-C. Lien and P.-T. Shaw (2006b) Assessing the west ridge of Luzon Strait as an internal wave mediator, Journal of Oceanography. [Submitted, refereed]